

## NATURE OF DAMAGE AND ~~ITS~~ IT'S ~~THE~~ THE MANAGEMENT OF FALL ARMYWORM (*SPODOPTERA FRUGIPRDA*) on MAIZE CROP A REVIEW

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### Abstract:

Fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae), is a polyphagous pest which is has arisening as one of the major threats to agricultural crop production. It has around 80 host species that cause severe damage to cereals and vegetable crops. This pest was first discovered in Africa (2016) and first collected and reported in Madhya Pradesh at Research Farm RVSKVV, Gwalior of the August Month in 2019-20. The *S. frugiperda* larvae el are found in newly grown leaves, leaf ves whorls, tasseling or cobs according to their growth stages. Scrape leaves, pin hole symptoms due to early larval stage and pane window symptoms whereas in the later vegetative stages due to larvae el of fall armyworm, damage results in skeletonized leaves and serious ly windows in whorls. Whereas whether condition increase for insects infestation firm is good for pest and could cause up to about 100% losses in maize crop but not control in the time.

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Normal investigation, push and pull method, light traps are used, common botanicals are available of neem locally available materials of ash & several suggested chemical pesticides with measured doses can be used for the management of *S. frugiperda*. In present a vital requirement for development of eco friendly environment, cost-effectively and collectively a adopted IPM strategies to ease ely the impacts of the *S. frugiperda*.

### Keywords:

Maize, Fall Armyworm, Nature of Damage, Management, Madhya Pradesh

### Introduction:

The fall armyworm, *S. frugiperda* (J. E. Smith) are found in the order Lepidoptera and family Noctuidae also known n as armyworm, *Spodoptera frugiperda*, it is polyphagous pests (Todd and Poole 1980; Cock *et al.*, 2017). *Spodoptera frugiperda* is an insect native to in tropical and subtropical areas of the America. The larvae el of fall armyworm feed on the leaves, stem and vegetative parts of more large than 100 crop species (CABI, 2017). Its emergence in d Africa is are sudden in Africa during in early on 2016, and it was whereas, first reported in central and western Africa (Goergen *et al.*, 2016). Within a year fall

armyworm was reported in most of Sub-Saharan Africa (Day *et al.*, 2017). It is economically ~~devastating and pest-as~~ a ~~re~~able ~~cause of~~ aggressive food ~~in~~security in the world (Devi, 2018). *Spodoptera frugiperda* ~~has~~ ~~can~~ ~~be~~ ~~migrating~~ to a wide range of ~~in~~ geographically areas (Goergen *et al.*, 2015, 2018 and Sharanbasappa *et al.*, 2018). ~~A whole~~ ~~It is~~ ~~one~~ generation ~~aggregation~~ of adult moths can migrate more than 500 kilometres (300 miles) with ~~the~~ help of air current before they are ready for oviposition (FAO 2017; Pogue, 2002; Prasanna *et al.*, 2018). It ~~has the ability to~~ ~~is~~ ~~very~~ ~~extremely~~ ~~attack~~ ~~son~~ ~~crops~~ of ~~the~~ gramineae family i.e. Maize (Andrews, 1980). ~~More~~ ~~Larger~~ than eighty ~~various~~ host plant species are ~~susceptible~~ ~~also~~ ~~initiate~~ ~~to~~ ~~be~~ ~~attacked~~ by the pests (CABI, 2018). This pest attack mainly whorl part of Maize crop and bore in the cobs of later stages of the crops which reduced the yield, quantity and quality of the maize crop (FAO, 2018). Entry of the ~~pest of~~ fall armyworm in India was first reported in the month of May, 2018 on the maize field at CoA, UAHS, Shivamogga, Karnataka after ~~that~~ various ~~other~~ ~~state~~ of India ~~also~~ ~~reported~~ ~~its~~ ~~presence~~ ~~and~~ ~~devastation~~ ~~like~~ ~~i.e.~~ TN, AP, MH and Telengana in ~~the~~ ~~crop~~ ~~of~~ Sugarcane ~~crops~~ and in Bihar, CG, Karnataka, Odisha, Gujarat and WB in ~~the~~ maize crop fields (CABI, 2019). The maize ~~which is~~ ~~at~~ the main crop of farmers of hilly areas, production of ~~about~~ 86 per cent has been used for consumption of human and animal feed for feed industries of ~~T~~ ~~arai~~ ~~areas~~ ~~pp~~roduction of 80 per cent in ~~the~~ ~~tarai~~ ~~in~~ ~~the~~ ~~T~~ ~~erai~~ is used for poultry and animal feed (Gurunget *et al.*, 2011; KC *et al.*, 2015).

In India, Maize is the 3<sup>rd</sup> important food crops after ~~than~~ Rice and Wheat. In India production of 22.23 MT mainly during Kharif which covers 80% areas. In India ~~it~~ contributes almost nine percent NFB. It is cultivated ~~mainly~~ ~~ted~~ throughout ~~in~~ the year in various states of the ~~various~~ country for ~~different~~ ~~various~~ purposes of grain, green cobs, sweet, baby ~~formular~~, pop corn and fodder in the Urban areas.

The main growing ~~sts~~ ~~ates~~ ~~of~~ ~~that~~ contributes more than 80 per cent of the total production of maize crop are AP, Karnataka, Rajasthan, MH, Bihar, UP, MP and HP apart from these states maize is also grown in J&K and North-Eastern states. Therefore, the maize crop has appeared as ~~the~~ ~~main~~ crop in the non-traditional areas i.e. peninsular in India as the state i.e. AP which ranks 5<sup>th</sup> in area and highest production (4.14 MT) and productivity (5.26 t ha<sup>-1</sup>) in the country although the productivity in some of the districts of AP is more or equal to the USA (Anno, 2012-13). Which supply ~~utmost~~ in terms of area possess a great hazard hence everyone should be ~~disturbed~~ ~~about~~ ~~the~~ ~~proper~~ ~~disturbed~~ ~~of~~ control and management of *S. frugiperda*.

### Systemic Position of FAW:

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Lepidoptera

Family: Noctuidae

Genus: *Spodoptera*

Species: *frugiperda*

### Identification of FAW:

The adult female lays 100-200 eggs on the undesirable and upper side of the leaves and covered by silky scales from female stomach (Sharanbasappa *et al.*, 2018) and fecundity of more than 2000 eggs from every one female. Hatching period of 2 to 5 days in optimum whether condition. Fall armyworm larvae are first green in colour after that they turn black with four black dots forming a square on the last 8<sup>th</sup> segment on the larval stages (CABI, 2019). The full mature larvae seen in an inverted "Y" shaped structure with white colour on the head and when examined closely the epidermis of the larvae is rough and granular in texture (Prasanna *et al.*, 2018 and CABI, 2017). The larval head is dark in colour with three light yellowish bands down the back (CABI, 2019). The caterpillar has four pairs of false abdominal legs (CABI, 2019). Adult female moth is slightly larger than male (FAO, 2018). A full developed larva has a size of 4 to 5 cm (CABI, 2019). Pupation takes place in the soil, cobs and plant debris which are reddish brown in colour. Adult male moths have whitish patches at the lower outer edges with whitish with dark decoration are shown on the inner surface of their wings. The female forewings have less marking with uniform range of grayish brown colour. The larvae of *S. frugiperda* was found to be cannibalistic with an average mortality of 40 per cent when maize crops are infested with 2 to 4 stage of larvae over a day period (Chouhan *et al.*, 2000). This insect pest larvae are highly active and fast feeding and are capable of causing extensive damage within a few days of infestation.

### Nature of Damage and Damage symptoms:

Regular fecundity of the pest at suitable ~~for~~ weather conditions are estimated to result in difficult damage to the maize crops (Goergen *et al.*, 2016), depending on the growth phase of the maize crop, larvae are deposited on young leaves, whorls portion of leaves, tasseling or cobs of maize crop (Goergen *et al.*, 2016). Larvae are voracious eaters in habitat and cause extensive damage by defoliating the plant. The larvae of fall armyworm scrape green matter of leaves and showed pin head holes similar to that of stem borer attack and pan windows feeding damaging symptoms of European corn borer attack (Sisay *et al.*, 2019). But later stage of crop damage results in skeletonization on leaves and shows high windows symptoms on whorls portion of the plant (Goergen *et al.*, 2016).

All plant portions are devoured by the larvae of *S. frugiperda*. The full mature stage of larvae found in the whorls of later host plants can feed on cob or kernels of maize crop, reduced yield, quality and quantity of host plant (Abrahams *et al.*, 2017; Capinera, 2017). While young leaves tissue is appropriate for survival and development of insect pest of maize whereas unsuitable on mature crop stage of host plant (Pannuti *et al.*, 2015).

In Nepal ~~pose~~ favorable weather conditions for pest development occur so, ~~there is~~ pest might cause on the average about 100 per cent loss in maize crop if it is not managed (CABI, 2019). Hruska and Gould recorded *S. frugiperda* highly damage caused extensive damage on maize crop and heavy yield losses of up to 70 per cent (Hruska and Gould, 1997).

### **Control methods of fall armyworm:**

#### **Investigation:**

The first showed that the seedling phase of maize. At nursery to start early whorl phase of the host plant (3-4 weeks after appearance). Act can be taken if 5 per cent hosts are damaged. At middle whorl portion to late whorl portion phase (5-7 weeks after appearance) - Act can be taken condition 10 per cent whorls are newly damaged in middle whorl phase and 20 per cent whorl damaged in later whorl phase. On tassels and post tassels (silking phase or milky stage of the crop) - Do not used chemical insecticides. However 10 per cent cobs damaged require several ecofriendly action (collection and destruction of egg or larvae). (ICAR, 2019).

#### **Cultural:**

It is a major component ~~key~~ of the fall armyworm management strategy. In winter ~~they~~ ~~are~~ killed by exposing larvae ~~or pupae~~ ~~to~~ ~~with~~ the upper soil surface and lowers the chance of incidence of the fall armyworm. A mechanical and cultural practice engage preventing later planting of host plant cobs ~~that~~ are highly infested due to fall armyworm than the early stage of planting (Bilbo, 2019). Intercroping ~~maize~~ ~~with other plants~~ and crop rotation ~~are also~~ recommended ~~to~~ minimize ~~ing~~ ~~i~~ ~~the~~ infestation of fall armyworm (FAO, 2018). The management ~~of~~ fall armyworm CIMMYT ~~requires anis~~ ~~looks for the~~ efficient ~~and~~ effective method of Push and Pull cropping system which ~~it is~~ ~~uses~~ ~~measured~~ a vital climate smart technology (Pradhan *et al.*, 2019). CIMMYT ~~are~~ ~~uses~~ two non host plants i.e. Napier-grass (*Pennisetum purpureum*) and Silver leaf Desmodium legumes (*Desmodium uncinatum*) from research control of fall armyworm in Kenya, Uganda and Tanzania. ~~The~~ ~~cause~~ study confirms ~~the~~ superiority of push pull technology for ~~the management~~ ~~d~~ of *S. frugiperda*. From the research ~~the~~ ~~in~~ control of Fall Army Worm in Kenya, Uganda and Tanzania, studies have confirmed superiority of push-pull technology in controlling of FAW ~~in~~ relation to ~~any~~ other ~~any~~ non host plant ~~and~~ mixing cropping system strategies (Hailu *et al.* in Press). It ~~has also~~ ~~shown that is~~ ~~providing~~ good soil health and adequate moisture ~~are~~ ~~is~~ critical. They are necessary to sow ~~a~~ healthy host plant material, which can improved ~~and help~~ withstand pests infestation and damage (ICAR, 2019).

#### Physical:

Continuous ~~of~~ monitoring of the pest activity ~~has prompted~~ successful achievement of ~~the IPM program is not possible~~. Setting light and pheromones traps ~~have also been~~ ~~are~~ found ~~to be~~ most effective in pest monitoring of *S. frugiperda* (Prasanna *et al.*, 2018). Use of black light traps can also be used to capture adult moths of fall armyworm (Hunt *et al.*, 2001; Qureshi *et al.*, 2006).

#### Mechanical:

Investigation for damage is special~~l~~y important for this pest because it feeds rapidly and ~~it is~~ highly destructive. Hand picking of the egg masses during regular monitoring of the field ~~is~~ helpful to manage the pest population in small scale and has ~~been~~ ~~proven~~ ~~d~~ somewhat successful (Rwomushana *et al.*, 2018). In Ethiopia, 15 per cent of the farmers practiced only handpicking for fall armyworm control (Kumela *et al.*, 2019). Setting of 5 pheromone traps/ acre and ~~the~~ ~~in~~ installation of one light trap/ ha during night hours to monitoring the adult moth activity in and around maize fields. ~~Another study~~ ~~Used~~ ~~showed that~~ 15 pheromone traps per

acre were used for mass trapping of the pest (ICAR, 2019) and it was found to be effective in the management of fall armyworm on maize crop fields, the farmers were advised to make installation fifty pheromone traps per hectare and lures will be changed after forty days according to (JAU, 2019).

### **Botanical:**

Use of botanical insecticides are mostly seen in developing countries and it is very safe, cheap and ecofriendly than the insecticides but may be subject to result in effect of weather conditions, costly, and may lead to resurgence and pest resistance against the pesticides (Arya and Tiwari, 2013). Many botanical insecticides are used for pest control like *Milletia ferruginea*, Neem products, Jatropha, Tobacco, sawanti and *Croton* and have proved to be successful into insect pest management (Jirnci, 2013). Similarly the larvae of fall armyworm had high mortality when NSKE was used (Silva *et al.*, 2015). A group of researchers posited that the *A. ochroleuca* (Papaveraceae) ethanolic extracts caused fall armyworm mortality due to a reduction in feeding and slowed down larval growth (Martinez *et al.*, 2017).

Tobacco extract was reported to have highest larval mortality rate i.e. 66% and *Lippia javanica* (66%) by contact toxicity tests and highest larval mortality by feeding bioassay test was obtained when *L. javanica* (62%) and Tobacco (60%) were used (Phambala *et al.*, 2020). Many plant extracts were used as a botanical insecticide but only few are commercialized and widely used and found to be effective. Neem products and pyrethrin are the very most important widely used products some other products are rotenone, garlic, nicotine, rianodine, quassia and so on (Isman, 1997). Small holder farmers in America use of ash, sand, sawdust or dirt into plant whorls part proved effective management of larval of fall armyworm (FAO, 2018).

### **Biological:**

Use of entomopathogenic fungus of *Metarhizium anisopliae* and *Beauveria bassiana* are effective against eggs and second – instar larvae of *S. frugiperda* (Komiviet *et al.*, 2019). *B. bassiana* caused moderate mortality of 30% to second instar larvae and the egg mortalities caused by *M. anisopliae* was 79.5-87.0% under laboratory conditions. Use of SfMNPV and use of predatory insects and parasitic wasps (parasitoids), use of genetically modified crops containing bacteria of *Bacillus thuringiensis* genes that produce

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proteins that are toxic to the larvae of fall armyworm (Day *et al.*, 2017) are some of the important biological controls. Use of important predatory insects are *Chrysoperla*, lady bird beetles, flower bugs and ants (FAO, 2018). In situ protection of natural enemies by habitat management: increase the plant diversity by intercropping with pulses and ornamental flowering plants which help in buildup of natural enemies. Eggs, larvae and pupae of fall armyworm are attacked by several species of parasitoids. Release of egg parasitoids *Telenomus* sp. and *Trichogramma* sp. are recommended for many countries. Augmentative release of *Telenomus rumus* and *Trichogramma pretisomon* @ 50,000 per acre at weekly intervals (ICAR, 2019).

Use of effective control of fall armyworm on maize crop, the farmers are advised to use ~~Spray of~~ three sprays of *B. bassiana* 15 WP ( $2 \times 10^6$  cfu/g) @ 4 kg OR *Nomuraearileyi* 1.15 WP ( $2 \times 10^6$  cfu/g) @ 3 kg + *SfNPV* 450 LE 1 lit first at initiation of pest population and subsequent two sprays at 10 day interval (JAU, 2019). Entomopathogenic fungal formulations are suitable at 5 per cent damage in seedling to early whorl stage and 10 per cent cob or tassell infesting with entomopathogenic fungal and bacteria. Spray of *Metarhiziumanisopiae* @ 2.5-3 kg/ha or *Nomuraearileyi* rice grain ( $1 \times 10^8$  cfu/g) @ 1-1.5 kg/in whorl application at 15-25 days after sowing and 1-2 sprays at 10 days interval depending on pest infestation and the bacteria *Bacillus thuringiensis kurstaki* @ 1.0 kg/ha or 400 g/ acre application (ICAR, 2019).

#### Chemical:

If seed is treated with Cyantraniliprole 19.8% + Thiamethoxam 19.8% @ 4 ml/kg of seed for 2-3 weeks after germination (ICAR, 2019). To manage fall armyworm spray Emamectin benzoate 5% SG @ 5 gm/10 litre of water or Thiodicarb 75% WP @ 10 gm/ 10 litre of water or Spinectoram 11.7% EC @ 10 ml/ 10 litre of water first at initiation of pest infestation and second at 10 days interval (JAU, 2019).

*Spodoptera frugiperda* can be controlled by applying synthetic insecticides (Blanco *et al.*, 2014, 2010). The use of chemical insecticides in the management of the pest is not at all economical in case of *S. frugiperda* as frass of this insect may become so highly that it can create a "plug" which reduces the effectiveness of insecticide and may not reach into the whorl where the larvae may be feeding (Day *et al.*, 2017). But, it is essential extremely severe and/or the plants are under stress infestation. When 75 per cent of the whorl portion of host plants shows infestation sign due to feeding of fall armyworm and larvae are smaller and the

host plants are under stress, pesticides may be advisable (CABI, 2019). Chemical insecticides are not used at day time as the pest is nocturnal (Day *et al.*, 2017). Threshold level are not still considered before jumping off to chemical control and this may lead to plant damage, resistance development and also risk to human and environment (Togola *et al.*, 2018). Spray of 5 per cent NSKE or Azadirachtin 1500 ppm @ 5 ml per litre of water at first whorls of host plant in seeding to early whorls phase reduce the hatching per cent of freshly lay eggs of fall armyworm. Spray of emamectin benzoate @ 0.4 gm or Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% EC @ 0.5 ml or Chlorantraniliprole 5% SC @ 0.3 ml per litre of water to manage second and third instars larval stage at 2<sup>nd</sup> window of middle whorl to later whorl stage. Used of recommended poison baiting to manage later instars larval of fall armyworm at second whorl windows and prepared baiting mixture of 10 kg rice bran + 2 kg jaggery with 2-3 litre of water for 24 hrs to ferment and add 100 gm Thiocarb just half an hour before applied in the maize field crop. Pesticides control measured not cost effective at third window stage of eight weeks after appearance to tasseling and post tasseling stage of the host plant crop. Advised for farmers' use of hand picking of the larvae of fall armyworm in maize field. All the insecticide spraying should be directed towards whorls and either in the early hours of the day or in the evening time (ICAR, 2019).

#### **Conclusion:**

*Spodoptera frugiperda* has the capability to breed very fast, migration and feeding on the wider host plants, it is very difficult to control measures. But, there are many traditional ways of managing the pest population as reported in other parts of the world that can potentially be adapted or validated and used in Madhya Pradesh. While the loss estimation of the pest infestation in Madhya Pradesh is not calculated yet (CIMMYT) has been working to managing the pest population in Madhya Pradesh through evaluation of push-pull strategy in which Soybean is cultivated with maize crop. However, single control method is not sufficient to control this pest population; IMP strategies should be considered while fighting against this pest population infestation.

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**Egg laying**

**Damage with larva**

**Larva of FAW**



**Damaged**

**Visit of Farm Committee**



**Rearing of Larvae**

**Larvae of FAW**

**Pupae of FAW**

Plate 1 : Culture of *Spodoptera frugiperda* and observation of damage in maize crop